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        Disorder (ASD)

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14. ABSTRACT

The purpose of this Idea Development award is to evaluate the additive benefits of "automated feedback" and eye tracking to "standard" (human-directed training) of driving skills for those who are diagnosed with high functioning autism and have a learner's permit. The goal for year 2, which began when funding arrived on Sept 30, 2013, was to examine the effects of eye-tracking feedback on training. This was accomplished by integrating the eye-tracking component with the standard training. To date we have completed 16 in the first phase of the analysis and have ten enrolled in the eye-tracking component of the study. Our partner site, the University of Iowa, also has training subjects using identical equipment and procedures for greater external validity of our findings. All of our participants have been able to engage in the driving training, and none have experienced simulation adaptation syndrome.

15. SUBJECT TERMS
Autism, Driving Safety, Driving Simulation, Automated Feedback, Eye Tracking

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Table of Contents

INTRODUCTION

Driving a motor vehicle is central to independent living but is a serious responsibility. Symptoms of Autism Spectrum Disorder (ASD) can make the acquisition of driving skills challenging and in some cases even impossible. While some individuals with ASD routinely operate a motor vehicle safely, others do not. Those who do drive typically took three times as long to acquire safe driving skills than the general public. However, there has been no systematic research addressing the questions of which individuals with ASD can learn to safely operate a motor vehicle, and what are good procedures to train adolescents with ASD to safely operate a motor vehicle. This project builds on a prior Department of Defense (DOD) project that demonstrated the feasibility of evaluating and training adolescents with ASD to drive using virtual reality driving simulation (VRDS).

The goals of the current study are to determine if the ability to learn how to safely operate a motor vehicle can be predicted with these simulator tests, whether the ability to benefit from virtual reality driving training can be predicted, and determine an optimal training package to promote the development of safe driving skills for ASD adolescents.

In this project, we aimed to recruit sixty adolescents composed of thirty from Iowa and thirty from Virginia, and evaluated their critical cognitive abilities and initial driving abilities on the simulator. These evaluations, along with an on-road test, were repeated two months later. In between these two evaluations, all of the ASD adolescents proceeded with the routine on-the-road training required by the Department of Motor Vehicles to secure an independent driver's license. Some of these adolescents also received our "standard" training on a virtual reality driving simulator; whereas others received different elements of our virtual reality simulation training. A successful outcome will allow parents and adolescents to know the probability of eventual acquisition of safe driving skills, as well as effective ways to develop safe driving skills.

KEYWORDS

- autism
- autism spectrum disorder
- driving
- driving simulator
- virtual reality driving simulation
- assessment
- training

ACCOMPLISHMENTS

What were the major goals of the project?

The goals of the current study were to determine if the ability to learn how to safely operate a motor vehicle could be predicted with these cognitive tests, whether the ability to benefit from

virtual reality driving training could be predicted, and determine an optimal training package to promote the development of safe driving skills for ASD adolescents.

What was accomplished under these goals?

We recruited ASD adolescents and young adult subjects who had secured their driving learner's permit but not yet their full license and assigned them to the following groups:

1. Routine driving training (***RT***)
2. Routine (Standard) VRDS training (***VRDS-T***)
3. Routine VRDS training with automated, computer-generated, performance feedback (***VRDS-A***)
4. VRDS training complemented with eye tracking (***VRDS-E***)

Figure 41. Idea Development Study Flow Chart

- Recruit/Consent 60 ASD novice drivers: 30 at UVA and 30 at UI
- **Pre-Assessment**: VRDS, Symptoms, Executive Functioning, Driving Avoidance
- VRDS-T (Standard)
- VRDS-A (Automated Feedback)
- **Post-Assessment**: VRDS & on-road assessments
- RT Group — Crossover → VRDS-E (Eye-Tracking)
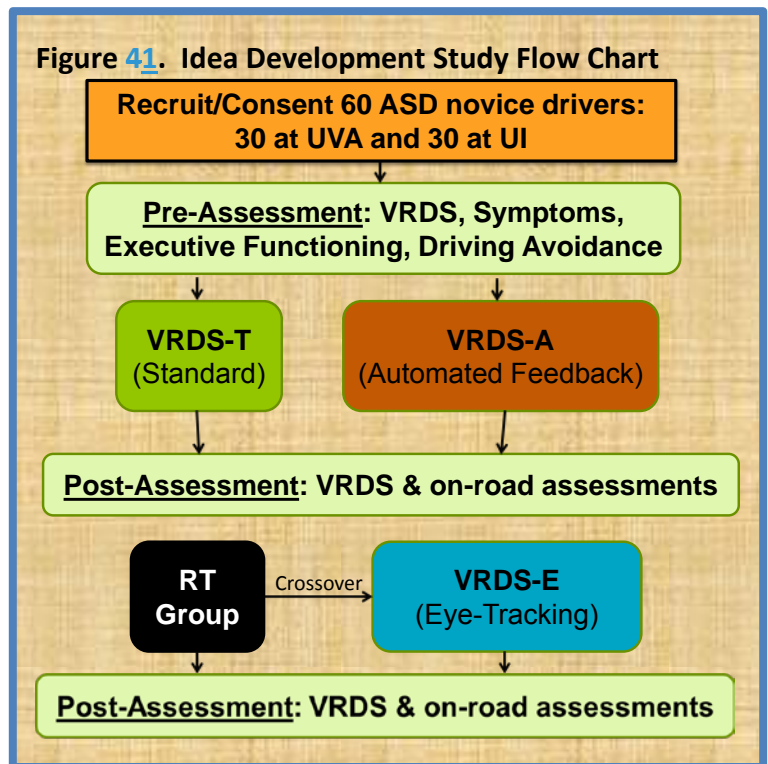- **Post-Assessment**: VRDS & on-road assessments

We have recruited all subjects and concluded three of the groups. We are now finishing Group #4, VRDS training complemented with eye tracking.

We have also submitted a DoD application for an ASD Randomized Clinical Trial. In that application we included the following findings:

Idea Development Award

This multi-center (U.Va., University of Iowa [**U.I.**]) study was designed to test the following hypotheses: 1) compared to routine driving training (***RT***) required by the DMV, VRDS training + RT (***VRDS-T***) would lead to greater improvement in driving safety and less driving anxiety, 2) VRDS-T augmented with computer-generated automated feedback (***VRDS-A***) would be superior to VRDS-T. Automated feedback involves the simulator detecting in real-time when the trainee's performance exceeds either legal (speed limit) or normative (extent of swerving) guidelines and immediately provides the trainee such feedback (e.g. "You are driving too fast"), 3) eye tracking feedback (***VRDS-E***) would significantly augment either VRDS-T or VRDS-A, whichever was found to be better. VRDS-E involves having the trainee wear Mobile Eye tracking glasses that record eye position to determine where the driver is looking. Playback of this video allows the trainee to view where s/he was looking during any part of the drive and facilitates training where to look if errors exist.

As seen in Figure 1, twenty participants were recruited at each site and then randomized to either ten training sessions of VRDS-T or VRDS-A. Trainees were assessed pre- and post-training in terms of operational and tactical driving performance, driving anxiety, and on-road performance

by an examiner blind to the training conditions (on-road assessment was only performed post-training). Subsequently, ten additional ASD novice drivers were recruited at each site. These participants served as RT controls, with pre- and post-assessment separated by two months. These subjects were crossed over to the VRDS-E condition and evaluated.

Currently, we have recruited all subjects, completed assessments of all VRDS-T, VRDS-A and RT, and have finalized half of our VRDS-E participants.

Preliminary Analyses:

Hypothesis 1 Results: VRDS-T led to significantly better post-assessment tactical composite scores (ANCOVA co-varying baseline performance p= .008). Figure 2 illustrates that at post-assessment, performance with RT was worse than the average of all drivers, while performance with VRDS-T was much better than the average. In terms of on-road performance, more RT participants declined taking the test compared to VRDS-A participants, and more VRDS-T participants passed the on-road test (see Figure 3). In terms of driving anxiety, at post-assessment, SAD scores demonstrated a more positive attitude towards driving following VRDS training (Figure 4).

Figure 2. Outcome of VRDS training program, demonstrating that VRDS-T was superior to RT (p<.01), as was VRDS-A (p<.05), and VRDS-E (p<.05). Training groups were not significantly different.
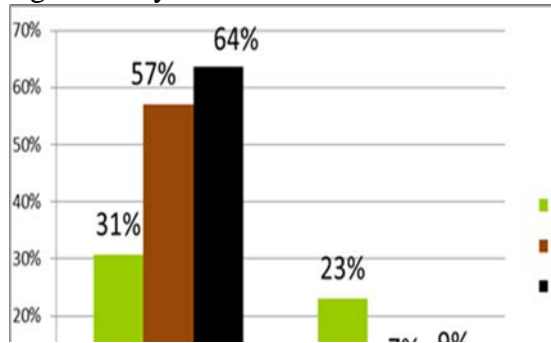
Figure 3. Percentage of participants opting out/refusing to take the on-road tests and percentage that passed the blinded on-road test.
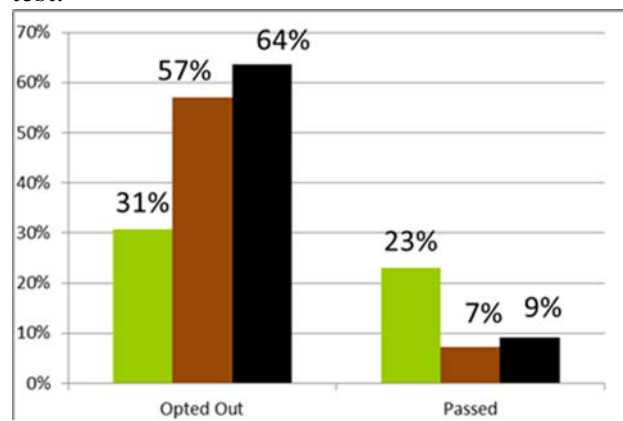
Hypothesis 2 Results: Those receiving VRDS-A were only marginally superior to those receiving RT (p=.059), and automated feedback did not improve VRDS-T (Figure 2).

Hypothesis 3 Results: As seen in Figure 2, after collecting half of the VRDS-E data, it appears that in its current form, required eye-tracking feedback did not significantly enhance efficacy of VRDS-T.

Figure 4. SAD scores were significantly more positive in VRDS-T than in Controls (p=.02).
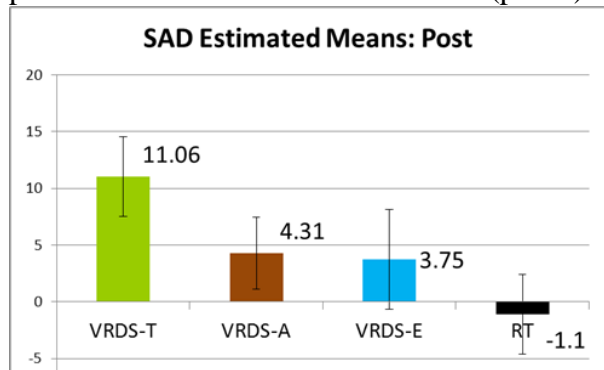
Discussion

As we have demonstrated with novice drivers without ASD (Cox et al, 2009) and with wounded warriors recovering from TBI, VRDS-T improved driving safety above and beyond RT. We hypothesized that computer-generated feedback would be more palatable than human-generated feedback to those with ASD, but this was not the case. This is probably due to the implementation of the automated feedback being in its infancy. While both trainers and trainees reported that the automated feedback was generally a good idea and useful, the system gave two types of frustrating and misleading feedback: 1) indicating a turn signal was not used when the turn signal had been activated, or indicating a wrong turn when the correct turn had been made, and 2) indicating that the driver was not maintaining lane position when driving on a curvy road, merging onto the highway, avoiding road hazards, or pulling off the road for an emergency. Software modification will correct these issues.

As for the benefits of trainees receiving eye-tracking feedback, preliminary analyses indicate that giving feedback to all subjects on all tactical driving elements does not significantly improve VRDS-T.

From the Idea Development award we learned that VRDS-T can significantly improve the driving safety of novice drivers with ASD, and this is not enhanced by the current version of automated feedback or the routine use of eye-tracking. However, informal feedback from trainees indicates there are some potential benefits derived from some parts of these adjunctive elements for some trainees.

What opportunities for training and professional development has the project provided?

The project was not intended to provide training and professional development opportunities

How were the results disseminated to communities of interest?

We are in data collection, so no results have been professionally disseminated.

What do you plan to do during the next reporting period to accomplish the goals?

We have been granted a no-cost extension for six months. During this time, we anticipate finalizing data collection and data analysis, along with manuscript submissions.

IMPACT

What was the impact on the development of the principal discipline(s) of the project?

Nothing to report

What was the impact on other disciplines?

Nothing to report

What was the impact on technology transfer?

If we document that our current simulator can assess and train driving competence of those with ASD, then it is reasonable to assume that other simulator companies will develop new capabilities to enhance this assessment and training, much like Henry Ford stimulated the development of mass produced automobiles.

What was the impact on society beyond science and technology?

The volunteer population for this study is late adolescents and young adults with ASD who have earned a learner's permit for driving, i.e. had the basic intellectual and social abilities to successfully navigate through the DMV process of passing a driving knowledge and vision test. While all children with ASD pass through this age window, not all will have the capabilities to achieve this milestone. Those who do achieve this milestone face the challenge of developing adequate skills to safely control a one-ton vehicle traveling through time and space while negotiating expected and unexpected road, signal, and traffic demands and maintaining control of both the vehicle and oneself. This is no small achievement when considering several common characteristics of ASD that impact driving: 1) difficulty with motor planning and coordination interferes with steering, accelerating, judging time and distance, braking, etc., especially when two or more of these tasks must occur simultaneously; 2) hyper-focus and limited attention flexibility/shifting compromises the ability to concentrate on keeping the car in the correct lane, maintain an appropriate distance from the lead car, and attend to the stoplight ahead, among the many other demands of driving; and 3) a desire for routine, structure, and rules presents a substantial problem when the driving routine is disrupted, e.g., when encountering a detour. The ability to earn a full driver's license opens new social, occupational, and personal opportunities and responsibilities, as well as real risks to one's own and others' physical safety. Therefore, it is

paramount that these novice drivers have training in the safe operation of a car that taps their abilities while accommodating to their challenges. Virtual Reality Driving Simulation (VRDS) is capable of breaking down the complex task of driving into systematic training elements that can be progressively layered as competence is achieved, while safely exposing the trainee to both challenging and potentially dangerous situations. VRDS allows objective assessment and feedback of performance. This non-judgmental and non-emotional mode of training is an ideal fit for those with ASD, and we have demonstrated that it leads to improved driving skills of adolescents in general, as well as military personnel recovering from a traumatic brain injury and young people with ASD. We propose the first systematic, comprehensive assessment of how VRDS can be used to evaluate an individual's capability to learn how to safely drive a car and promote the learning of safe driving skills that lead to the acquisition of an independent driver's license and a subsequent low rate of driving mishaps. If this effort proves effective, it could revolutionize this developmental milestone by providing a documented, systematic, standardized education program in driving, which is generally taught by well-intended but frequently ill-prepared trainers who have to rely on emersion of a novice driver into real world driving situations that are potentially dangerous. VRDS training provides systemic training modules with a standardized training manual, so any competent trainer could provide a standardized and effective assessment and training program for any ASD individual who has achieved a learner's permit. This process of obtaining a permit and VRDS training to improve driving skills with an end goal of securing a full driver's license promotes autonomy, social contribution, and self-esteem throughout their lives. Further, this training could be made available to those ASD drivers who have acquired a driver's license but still do not feel comfortable/competent behind the wheel.

CHANGES/PROBLEMS:

Nothing to report

PRODUCTS:

Nothing to report

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Name:	
Daniel Cox	No Change
Ron Reeves	No change
Matt Moncrief	No change

Tim Brown	No change
Gary Gaffney	No change
Rose Schmitt	No change

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Nothing to report

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